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(58) Field of Search
UK CL (Edition O) H1D DKFA DKGC DKGE DKGX DKJA DKJB DKJC DKJD DKJF DKJJ DKJK DKJX
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(54) Inductive output tubes

(57) An inductive output tube has an input cavity 7 having a channel 32, e.g. defined by part of the cavity wall 30 and other walls 33 and 34 to give a U-shaped cross-section. The channel 32 contains high frequency energy absorbing material such as ferrite loaded silicone rubber 35. This prevents unwanted oscillations and because of the large surface area of the channel in contact with the material 35 it is particularly efficient. Other configurations and locations of the channel are also possible and the absorbing material may occupy only part of the channel providing that it is in contact with the surfaces of the channel walls.

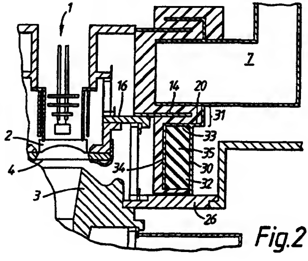

Fig.2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

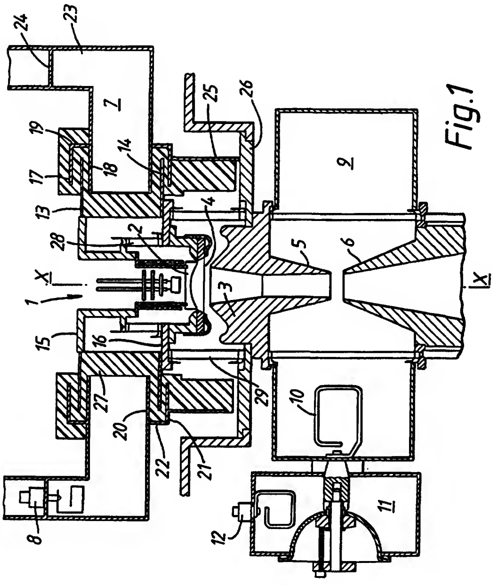
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Fig.1

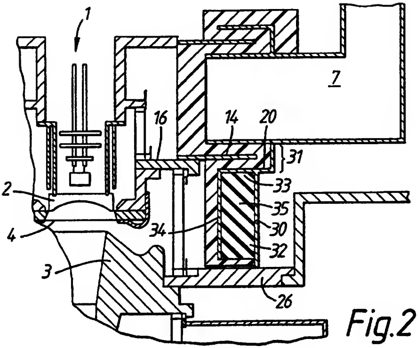

Fig.2

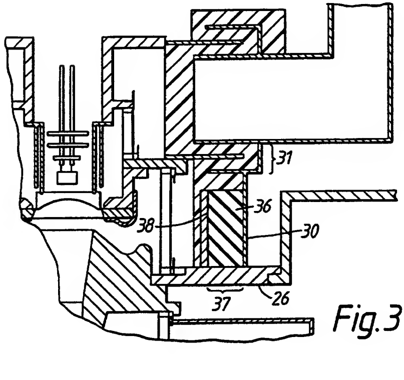

Fig.3

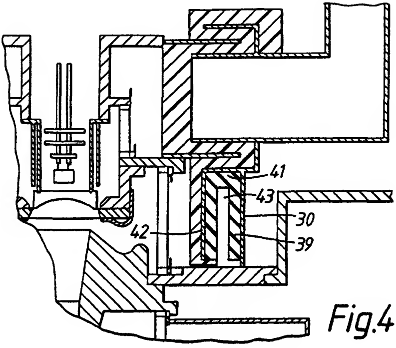

Fig.4

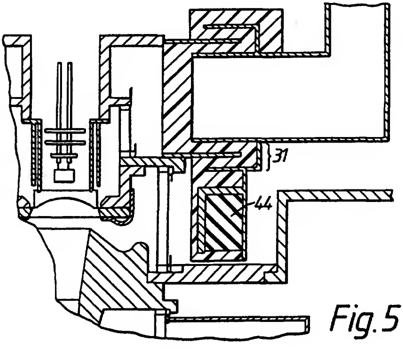

Fig.5

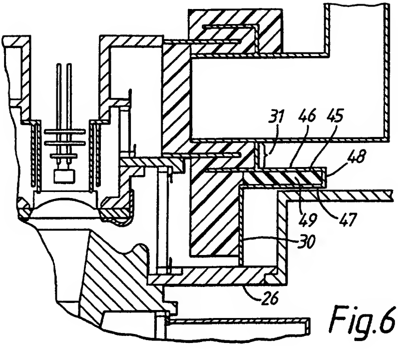

Fig.6

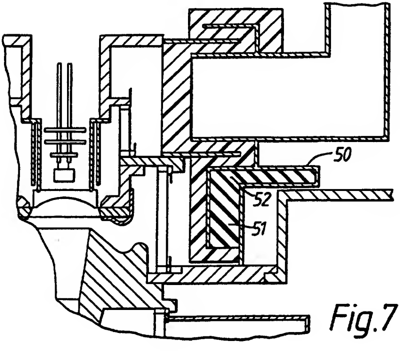

Fig.7

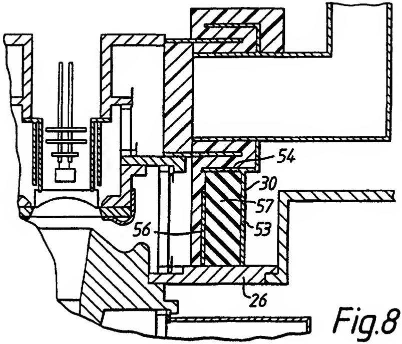

Fig.8

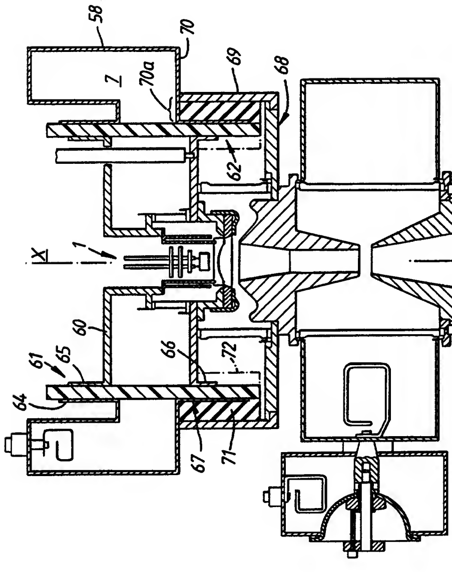

Fig.9

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INDUCTIVE OUTPUT TUBE ARRANGEMENTS

This invention relates to inductive output tube arrangements and more particularly to input resonator cavities for such tubes at which high frequency energy is applied.

The present invention is particularly applicable to inductive output tube devices

(hereinafter referred to as "IOT's"). An IOT device includes a tube having an electron gun arranged to produce a linear electron beam and a resonant input cavity at which an r.f. signal to be amplified is applied to produce modulation of the beam at a grid of the electron gun. The resultant interaction between the r.f. energy and the electron beam produces amplification of the high frequency signal which is then extracted from an output resonant cavity.

One known IOT device is schematically illustrated in longitudinal section in Figure 1. The IOT includes an electron gun 1 which comprises a cathode 2, an anode 3 and a grid 4 located between them. The electron gun is arranged to produce an electron beam directed along the longitudinal axis X-X of the arrangement. The IOT also includes drift tubes 5 and 6 via which the electron beam passes before being collected by a collector (not shown). A cylindrical annular input cavity 7 is arranged coaxially about the electron gun 1 and includes an input coupling 8 at which an r.f. signal to be amplified is applied. An output cavity 9

surrounds the gap between the drift tubes 5 and 6 and includes a coupling loop 10 via which an amplified r.f. signal is extracted and coupled into a secondary output cavity 11 from which the output signal is taken via an output coupling 12.

The IOT includes two transversely arranged annular plates 13 and 14 which each form part of respective rf chokes. The first plate 13 is connected via conductive spring fingers (not shown) to a tubular member 15 which mechanically supports the cathode 2 and is maintained at cathode potential. The other transverse plate 14 is connected via spring fingers to a support 16 of the grid 4 and is at the grid potential. An outer portion is electrically separate from the inner portion and comprises transverse annular plates 17 and 18 connected by a cylindrical axially extensive wall 19 and arranged coextensively with part of the plate 13. The outer body portion also includes further transverse plates 20 and 21 connected by a cylindrical wall 22 which are partially coextensive with the plate 14 which is electrically connected to the grid 4. The two rf chokes formed by the interleaved structures reduce leakage of the applied high frequency energy from the cavity 7.

The cavity 7 further includes an axially extensive portion 23 having a movable tuning door 24 to permit the frequency of operation to be altered. It also includes a cylindrical wall 25 coaxial with the axis X-X and extensive in the region between the grid support 16 and anode support 26.

Dielectric material 27 is located between the interleaved transverse plates of the rf chokes to provide structural support and electrical insulation.

Ceramic cylinders 28 and 29 surround the electron gun assembly and define part of the vacuum envelope.

In use, a d.c. voltage, typically of the order of 30-40kV is established between the cathode 2 and the anode 3 and an r.f. input signal is applied between the cathode 2 and the grid 4. The r.f. choke defined by plates 14, 20 and 21 reduces coupling between the cathode/grid region and the anode 3. However, in some circumstances this may be insufficient to completely prevent leakage of r.f. energy and coupling between the two regions and, as a result, unwanted oscillation of the electron beam may occur. Such oscillation may not only decrease the operating efficiency of the tube but may also cause arcing within the tube sufficient to damage or disable it.

Our earlier application, published under serial number GB -A-2 279 496, discloses some ways in which oscillation may be reduced. The present invention arose from considering whether unwanted oscillation may be reduced even more effectively or substantially eliminated. The invention is particularly applicable to IOTs but may also be advantageously employed in other types of electron beam tube arrangement.

According to the invention there is provided an inductive output tube arrangement comprising an electron gun assembly including a cathode and a grid for generating an electron beam; a substantially annular high frequency resonant input cavity arranged coaxially about the assembly; means for applying high frequency

energy to the resonant cavity to modulate the electron beam; and wherein a wall of the cavity includes a channel within which is located material capable of absorbing high frequency energy.

By employing the invention, unwanted oscillation may be reduced or eliminated as the lossy material within the wall may be arranged so that it tends to absorb energy which might otherwise be coupled between different parts of the tube, in particular between the cathode/grid region and the anode. The channel provides a large surface area in contact with the absorbing material and this is a significantly more effective configuration than would be the case if the material were simply carried on a surface as the high frequency energy travels around the channel walls. The invention thus provides a compact arrangement with better energy absorption than would be achievable in a device where the channel is not used. As suitable absorbing material is expensive, use of the invention may also lead to cost benefits, as a reduced amount may be used to achieve the same effect as absorbing material merely attached to a wall. A suitable absorbing material for use in the invention is a ferrite loaded dielectric material and preferably the dielectric material is silicone rubber. One suitable material loaded with dielectric particles is that designated as Eccosorb CF-S-4180 obtainable from Emerson and Cuming. This ferrite loaded silicone rubber material is a high loss material in the UHF and microwave ranges and is also capable of holding off high dc voltages of the order of several tens of kilovolts. Other absorbing materials may be used.

The silicone rubber for the absorbing material could be replaced by other

types of rubber or a resin, and could be loaded with one, or a combination of, the following: powdered iron, powdered nickel, silicon carbide, dispersed graphite or ferrite. Other materials having similar characteristics may also be suitable, and the dispersed material could be present in powder or particulate form, for example.

The channel may have one of a number of different cross-sectional configurations. In one preferred embodiment, it is substantially annular and has three sides in cross-section. The substantially U- or C-shaped channel thus provides a large surface area for contact with the absorbing material such that currents in the cavity wall may be absorbed to reduce unwanted oscillation. The absorbing material may wholly occupy the interior defined by the channel. In an alternative embodiment, the surfaces of the channel are in contact with the absorbing material but an inner volume within the channel is free from such material. This volume could be occupied by a non-lossy material such as silicone rubber or it could be an air space.

It has been found that only one channel is required to give good performance but in some electron beam tubes, two or more may be required.

Where the channel has three sides, facing sides may extend in the direction of the longitudinal axis along which the electron beam is directed or in a radial direction either inwardly into the cavity or outwardly from it. In one arrangement, the channel is partially radially orientated and partially extensive in an axial direction.

The channel may have other cross-sectional shapes, for example it could have a rounded wall to give a C-shaped section or could have more than three sides.

In one particularly advantageous embodiment of the invention, one wall of the channel also defines part of an rf choke means. This gives a compact arrangement and as the interior surfaces of the channel are those which are in contact with the absorbing material, the inclusion of the channel wall in the choke arrangement should not substantially adversely affect the effectiveness of the choke.

Preferably, the channel is located substantially in the region between supports for the grid and an anode of the electron gun assembly. It is particularly effective in this region in reducing the unwanted oscillations or substantially eliminating them.

Advantageously, the electron gun assembly is located within a vacuum envelope and the material is located outside the envelope.

According to a feature of the invention, a cavity arrangement for use with an inductive output tube comprises a wall which includes a channel within which is located material capable of absorbing high frequency energy.

As the material is located within a channel included in a wall defining the cavity, it can be arranged to be readily accessible for replacement, if necessary, or for upgrading an existing tube. The main body of the tube, including sections under

vacuum, may be kept in situ as set up for operation and the cavity wall removed for servicing elsewhere, if desired. During servicing, a replacement cavity wall can be fitted to the tube to enable operation to continue substantially uninterrupted whilst the servicing work is carried out separately. Thus, the positioning of the material on the cavity wall gives significant benefits in maintaining the tube in a serviceable condition whilst also enhancing its performance.

Some ways in which the invention may be performed are now described by way of example with reference to the accompanying drawings in which:

Figures 2 to 9 schematically illustrate parts of IOTs in accordance with the invention which include respective different configurations of the channel and absorbing material, with like references being used for like parts. Other portions of the IOTs are as shown in Figure 1.

With reference to Figure 2, an IOT has an electron gun assembly 1 with a cathode 2, grid 4 and anode 3. The IOT includes an annular input resonant cavity 7 arranged to receive high frequency energy to cause modulation of the electron beam. The cavity 7 includes a cylindrical cavity wall 30 which extends from a choke arrangement 31 to the anode support 26 in a longitudinal axial direction X-X along which an electron beam is generated during use. An annular channel 32 is defined by part of the cavity wall 30 and two other walls 33 and 34. The channel has a substantially U-shaped cross-sectional shape in which the facing surfaces are extensive in the longitudinal direction X-X and in which the wall which joins them is

located at their ends nearest the rf choke 31. The channel 32 is substantially wholly filled with ferrite loaded silicone rubber 35. The wall 33 which joins the two facing walls 30 and 34 of the channel is also included as part of the rf choke 31 in combination with plates 14 and 20. The region between the interleaved sections of the choke 31 is filled with dielectric material such as silicone rubber. Although in this arrangement the channel is completely filled with the absorbing material, in other arrangements it may extend only part way between the end wall 33 and the open end of the channel. However, such an arrangement is not as efficient. The channel 32 is located in the region between a grid support 16 and the anode support 26.

With reference to Figure 3, in another arrangement in accordance with the invention, a channel 36 is again defined by part of the cavity wall 30 between the choke 31 and anode support member 26 but in this case the two other sides of the U-shaped channel are formed by part 37 of the support plate 26 and a wall 38 extending from the plate 26 towards the choke 31. Again, the channel 36 is wholly filled with absorbing material.

With reference to Figure 4, an arrangement is shown which is similar to that of Figure 2 but in this embodiment, the absorbing material 39 does not wholly fill the channel 40 defined by walls 30, 41 and 42. The interior part of the channel is occupied by an air space 43 and the absorbing material 39 covers the interior walls of the channel 40.

In another embodiment shown in Figure 5 which is similar to the arrangement

of Figure 2, the channel 44 is orientated in the same way but in this arrangement the choke 31 is separate from the channel 44 and does not share a common component.

With reference to Figure 6, another arrangement in accordance with the invention includes an rf choke 31 and a cylindrical cavity wall 30 which adjoins the support 26 of the anode. A channel 45 is again of U-shaped cross-sectional area but in this case the facing wall 46 and 47 are extensive in a radial direction with respect to the longitudinal axis X-X of the arrangement. A wall 48 joins them to define the channel 45. In this embodiment the channel is adjacent the rf choke 31 but does not form part of it. Absorbing material 49 fills the channel. The channel 45 extends outwards away from the centre of the tube and thus increases the volume occupied by the IOT. In other embodiments (not shown) a radially extensive channel extends inwardly.

With reference to Figure 7 in another arrangement, the channel is of a more complicated structure having a transversely extending part 50 similar to that shown in Figure 6 in combination with an axial extending part 51 similar to that of the Figure 2 arrangement. This provides a large surface area over which the absorbing material 52 is in contact, the material filling the channel.

With reference to Figure 8, a channel 53 is defined by a part of the cylindrical cavity wall 30, the end plate 26 which supports the anode 3 part 54 of the rf choke 55 and a wall 56 extensive in a direction towards the rf choke 55 from the support

26. In this arrangement, therefore, the channel is substantially four sided, there being a gap between the part 54 and that the free end of the wall 56. Absorbing material 57 is enclosed within the channel.

In the arrangement shown in Figures 2 to 8, the rf chokes are shown as being made up of interleaved plates which are in a plane normal to the longitudinal axis X-X. However, in other arrangements, these may be replaced by axial rf chokes which, say, two cylinders are located one within the other to form a choke between them and are coaxial with axis X-X.

With reference to Figure 9, in another IOT in accordance with the invention, an electron gun 1 is again surrounded by an annular resonant input cavity 7. In this embodiment, the input cavity 7 comprises an outer body portion 58 and an inner body portion 60 maintained at a different potential to the first body portion. Two rf chokes 61 and 62 are included between the inner and outer body portions 58 and 60. Each of the chokes 61 and 62 is extensive in the direction of the longitudinal axis X-X along which in use an electron beam is generated. A ceramic tube 63 is arranged coaxially around axis X-X and forms part of chokes 61 and 62. Choke 61 includes copper metallised regions 64 and 65 on the outer and inner surfaces of ceramic cylinder 63. Choke 62 includes a metallisation layer 66 on the inner surface of ceramic tube 63 and a second metallisation layer 67 on its outer surface. The metallisation 67 extends over a greater axial length than the inner metallisation region 66. An anode support 68 has a section 69 which is connected to an annular plate 70 forming part of the outer body portion 58 of resonant cavity 7.

The wall 69, the inner part 70a of plate 70 and the outer metallisation layer 67 together define a channel within which is located ferrite loaded silicone rubber 71 or some other suitable rf absorbing material.

In another embodiment of the invention, a non-lossy dielectric material such as silicone rubber is located over part of the inner surface of ceramic cylinder 63 and over the metallisation layer 66 as shown by the broken line at 72.

In other arrangements similar to that shown in Figure 9, materials other than ceramic may form part one or both rf chokes. The dielectric material need not be continuous between both chokes. Also, the metallisation layers shown in Figure 9 may be replaced by metallic members affixed to the interposed dielectric material.

CLAIMS

1. An inductive output tube arrangement comprising an electron gun assembly including a cathode and a grid for generating an electron beam; a substantially annular high frequency resonant cavity arranged coaxially about the assembly; means for applying high frequency energy to the resonant cavity to modulate the electron beam; and wherein a wall of the cavity includes a channel within which is located material capable of absorbing high frequency energy.

2. An arrangement as claimed in claim 1 wherein the channel has three sides in cross-section.

3. An arrangement as claimed in claim 1 or 2 wherein two facing sides of the channel extend in the electron beam direction.

4. An arrangement as claimed in claim 1, 2 or 3 wherein facing sides of the channel extend in a radial direction with respect to the longitudinal axis of the electron gun assembly along which the electron beam is directed.

5. An arrangement as claimed in any preceding claim wherein the channel is substantially annular and coaxial with the electron beam path.

6. An arrangement as claimed in any preceding claim wherein one wall of the

channel also defines part of an rf choke means.

7. An arrangement as claimed in claim 6 wherein the rf choke means includes electrically conductive members extensive in a direction normal to the longitudinal axis of the electron gun assembly.

8. An arrangement as claimed in claim 6 wherein the rf choke means includes electrically conductive members extensive in a direction parallel to the longitudinal axis of the electron gun assembly.

9. An arrangement as claimed in claim 8 wherein ceramic material is located between axially co-extensive conductive members of the rf choke means.

10. An arrangement as claimed in claim 8 or 9 wherein at least one of the electrically conductive members comprises a metallisation layer.

11. An arrangement as claimed in any preceding claim wherein the channel is located substantially in the region between a support for the grid and a support for the anode of the electron gun assembly.

12. An arrangement as claimed in any preceding claim wherein the channel is substantially filled with material capable of absorbing high frequency energy.

13. An arrangement as claimed in any of claims 1 to 11 wherein the inner surfaces

of the channel are in contact with the material which is absent from an inner volume defined by the channel.

14. An arrangement as claimed in any preceding claim wherein the absorbing material is a ferrite loaded dielectric material.

15. An arrangement as claimed in claim 14 wherein the absorbing material is ferrite loaded silicone rubber.

16. An arrangement as claimed in any preceding claim wherein the electron gun assembly is located within a vacuum envelope and the material is located outside the envelope.

17. A cavity arrangement for use with an inductive output tube wherein a wall of the cavity includes a channel within which is located material capable of absorbing high frequency energy.

18. An inductive output tube arrangement substantially as illustrated in and described with reference to any one of Figures 2 to 9 of the accompanying drawings.

19. A cavity arrangement for use with an inductive output tube substantially as illustrated in and described with reference to any one of Figures 2 to 9.

The Patent Office

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Application No: GB 9613896.1 | Examiner: Martyn Dixon
Claims searched: all | Date of search: 20 August 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1D (DKGC,DKGE,DKGX,DKFA,DKJA,DKJB,DKJC,DKJD, DKJF,DKJJ,DKJK,DKJX)

Int Cl (Ed.6): H01J

Other: online: WPI, CLAIMS

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2279496 A	(EEV) see especially figs 4 and 5	1,2,4-8, 11-17
X	GB 2259708 A	(EEV) see especially fig 2	17
X	GB 1236719 A	(Varian) see attenuator 36 in cavity 35 in fig 2	17
X	EP 0660363 A	(Hughes Aircraft) see e.g. fig 7	17
X	EP 0627757 A	(Varian) see especially col 5, lines 33 et seq and col 10, lines 7-11	1 and 17 at least
X	US 5130206 A	(Hughes Aircraft) see e.g. col 5, lines 25 et seq	17
X	US 4529911 A	(Herfurth) see the whole document	17
X	US 4163175 A	(Tokyo Shibaura) see energy absorber 43	17

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